

Note: The first letter of each map unit indicates the general age of the unit:

H = Holocene (postglacial deposit; formed during the last 11,700 years). **P** = Pleistocene (deposit formed during glacial to late-glacial time, prior to 11,700 yr B.P. [years before

Artificial fill - Variable mixtures of earth, rock, and/or man-made materials used as fill for roads and airport runways. Usually shown only where large enough to affect the contour pattern on the topographic map. Minor artificial fill is present in virtually all developed areas of the quadrangle.

Wetland deposits - Peat, muck, silt, and clay in poorly drained areas. Map unit may also include some alluvial sediments along stream valleys.

Stream alluvium - Silt and sand deposited on the flood plain of Goose River. Locally

includes organic wetland deposits and probably underlies some of the mapped wetland areas along the river.

Marine delta - Pleistocene marine delta formed during flooding by the sea due to isostatic submergence of the land. Very low-angle sand and silt foreset bedding is mantled by trough cross-bedded sand, deposited by braided streams which flowed over the delta top as it prograded seaward. In places, may be mantled with unmapped thin eolian deposits. Four

deltas have been assigned unique geographic names listed below: Pmdh - Hadley Cemetery delta Pmdp - Paul Cemetery delta Pmdr - Harding Cemetery delta

Pmds - Shorey Cemetery delta

margin during recession of the late Wisconsinan ice sheet.

Glaciomarine fan - Sand and gravel deposited in a submarine environment at the glacier

Presumpscot Formation - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. This map unit commonly overlies the irregular surface of glacial till in a complex manner, so it is likely to include areas of till exposed at the ground surface.

Presumpscot Formation overlying sand and gravel - Areas of sand and gravel deposited by glacial meltwater streams in tunnels beneath the ice. The topography of these units approximates the location of sand and gravel buried by younger glacial marine silt and clay.

Till - Light- to dark-gray nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders; a predominantly sandy to silty diamicton containing some gravel. Generally found under most other deposits. Till reaches a thickness of 90 feet or more.

Thin-drift areas - Ruled pattern indicates areas where bedrock outcrops are common and/or surficial sediments are generally less than 10 ft thick. Mapped from air photos and ground observations. Actual thin-drift areas probably are more extensive than shown.

---- Contact - Boundary between map units. Most contacts are approximately located and

--- Upper limit of marine submergence - Shows highest elevation of sea level immediately following recession of the last glacial ice sheet from the quadrangle.

therefore indicated by dashed lines.

(k) k Kettle - Depression created by melting of large mass of buried glacial ice and collapse of

overlying sediments.

IIIIIIIIII Ice-margin positions - Shows an approximate position of the glacier margin during ice retreat

based on meltwater deposits, moraines, or positions of meltwater channels.

moraines. Mapped from field observations and Lidar imagery.

— - — Marine shoreline - Indicates a former shoreline formed in late-glacial time when relative sea

Meltwater channel - Channel eroded by a glacial meltwater stream. Arrow shows inferred

>>>> Axis of esker - Alignment of symbols shows trend of esker. Chevrons point in direction of former glacial meltwater flow.

End moraine crests - Shows linear ridges consisting of bedded sand and gravel interbedded with Presumpscot Formation silty clays and overlain by till on the ice-proximal faces of the

— Glacially grooved or fluted till - Formed beneath the glacier by erosion of till surfaces by boulders in the base of the ice scouring the till, or by obstructions on the till surface that allow for development of elongate till ridges parallel to ice-flow direction.

Glacial striation locality - Arrow shows ice-flow direction(s) inferred from striations on Glacial striation locality - Arrow shows ice-flow direction(s) inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. Where striation sets of different ages are present, the flagged arrows indicate older sets. Where striation sets of different ages are present, the flagged arrows indicate older sets.

USES OF SURFICIAL GEOLOGY MAPS

A surficial geology map shows all the loose materials such as till (commonly called hardpan), sand and gravel, or clay, which overlie solid ledge (bedrock). Bedrock outcrops and areas of abundant bedrock outcrops are shown on the map, but varieties of the bedrock are not distinguished (refer to bedrock geology map). Most of the surficial materials are deposits formed by glacial and deglacial processes during the last stage of continental glaciation, which began about 25,000 years ago. The remainder of the surficial deposits are the products of postglacial geologic processes, such as river floodplains, or are attributed to human activity, such as fill or other land-modifying features. The map shows the areal distribution of the different types of glacial features, deposits, and landforms as described in the map explanation. Features such as striations and moraines can be used to reconstruct the movement and position of the glacier and its margin, especially as the ice sheet melted. Other ancient features include shorelines and deposits of glacial lakes or the glacial sea, now long gone from the state. This glacial geologic history of the quadrangle is useful to the larger understanding of past earth climate, and how our region of the world underwent recent geologically significant climatic

changes for long-term planning efforts, such as coastal development or waste disposal. Surficial geology maps are often best used in conjunction with related maps such as surficial materials maps or significant sand and gravel aquifer maps for anyone wanting to know what lies beneath the land surface. For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or pottery. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or siting new homes may be better planned with a good knowledge of the surficial geology of the site.

and environmental changes. We may then be able to use this knowledge in anticipation of future similar

OTHER SOURCES OF INFORMATION

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Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Belfast Quadrangle, Maine

Surficial geologic mapping by Thomas K. Weddle

Digital cartography by

Susan S. Tolman

Robert G. Marvinney State Geologist

Cartographic design by **Robert D. Tucker Christian H. Halsted**

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Maine Geological Survey

Address: 93 State House Station, Augusta, Maine 04333 **Telephone:** 207-287-2801 **E-mail:** mgs@maine.gov **Home page:** http://www.maine.gov/dacf/mgs/

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SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 2.5 million and 11,700 years ago. The slowmoving ice superficially changed the landscape as it scraped over mountains and valleys (Figure 1), eroding and transporting boulders and other rock debris for miles (Figure 2). The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments

The most recent "Ice Age" in Maine began about 30,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement (Figure 3). Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 calendar years ago, soon after it reached its southernmost position on Long Island (Ridge, 2004). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by about 16,000 years ago (Borns and others, 2004). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present

elevations of up to 420 feet in the central part of the state. Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas (Figure 4) and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land rebounded as the weight of the ice sheet was removed, forcing the

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared (Figure 5). Maine's esker systems can be traced for up

to 100 miles, and are among the longest in the country. Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat (Figure 6).

The last remnants of glacial ice probably were gone from Maine by 12,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys (Figure 7). The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land (Figure 8), and worldwide sea level is gradually rising against Maine's coast.

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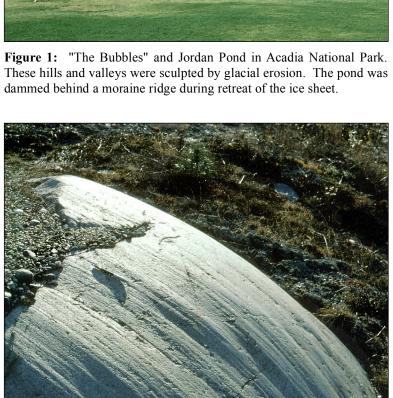


Figure 3: Granite ledge in Westbrook, showing polished and grooved surface resulting from glacial abrasion. The grooves and shape of the

ledge indicate ice flow toward the southeast.

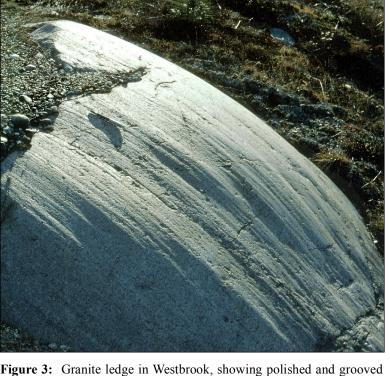




Figure 2: Daggett's Rock in Phillips. This is the largest known

glacially transported boulder in Maine. It is about 100 feet long and

estimated to weigh 8,000 tons.

Figure 4: Glaciomarine delta in Franklin, formed by sand and gravel washing into the ocean from the glacier margin. The flat delta top marks approximate former sea level. Kettle hole in foreground was left

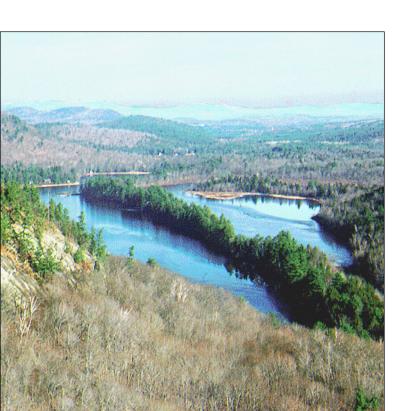
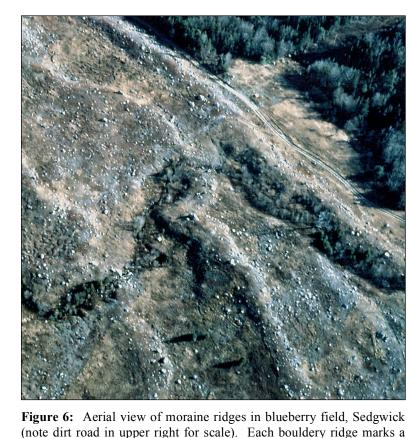


Figure 5: Esker cutting across Kezar Five Ponds, Waterford. The ridge consists of sand and gravel deposited by meltwater flowing in a tunnel beneath glacial ice.



position of the retreating glacier margin. The ice receded from right to



Figure 7: Sand dune in Wayne. This and other "deserts" in Maine formed as windstorms in late-glacial time blew sand out of valleys, often depositing it as dune fields on hillsides downwind. Some dunes were reactivated in historical time when grazing animals stripped the vegetation cover.



Figure 8: Songo River delta and Songo Beach, Sebago Lake State Park, Naples. These deposits are typical of geological features formed in Maine since the Ice Age.